BOARD OF STUDIES
NEW SOUTH WALES

2008
HIGHER SCHOOL CERTIFICATE EXAMINATION

Engineering Studies

Total marks – 100

General Instructions
- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A formulae sheet is provided at the back of this paper
- Write your Centre Number and Student Number at the top of pages 9, 11, 15, 17, 21, 25, 29 and 33

(**Section I**) Pages 2–7

10 marks
- Attempt Questions 1–10
- Allow about 20 minutes for this section

(**Section II**) Pages 9–27

70 marks
- Attempt Questions 11–16
- Allow about 2 hours for this section

(**Section III**) Pages 29–36

20 marks
- Attempt Questions 17–18
- Allow about 40 minutes for this section

Section I

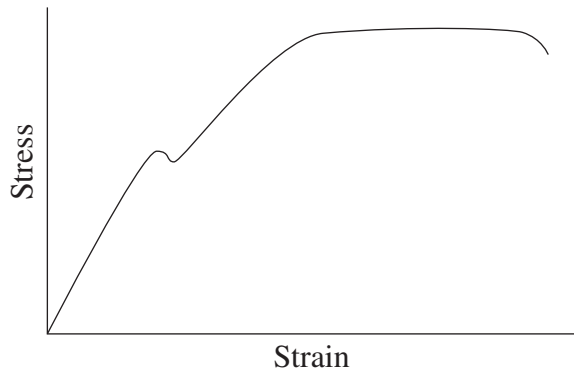**1** The graph shows the result of a test.

What does the graph typically represent?

(A) Shear test for polyethylene

(B) Hardness test for a composite

(C) Compression test for a ceramic

(D) Tensile test for low carbon steel

2 A forming process is used to manufacture continuous steel guard railing.
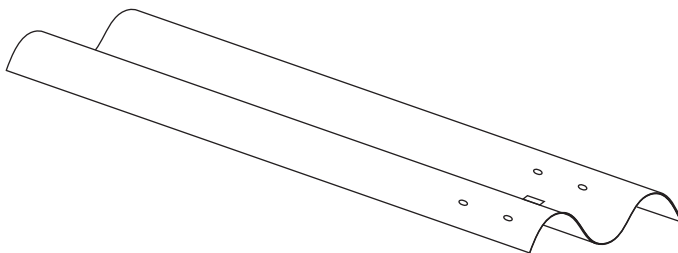
Which of the following identifies the name of a suitable forming process and the effect of the process on the material?

(A) Cold rolling and increase in hardness

(B) Hot rolling and increase in hardness

(C) Cold rolling and decrease in stress

(D) Hot rolling and decrease in ductility

3 To what depth will a 100 mm solid bar sink into water if it maintains an upright position and has a density half that of water?
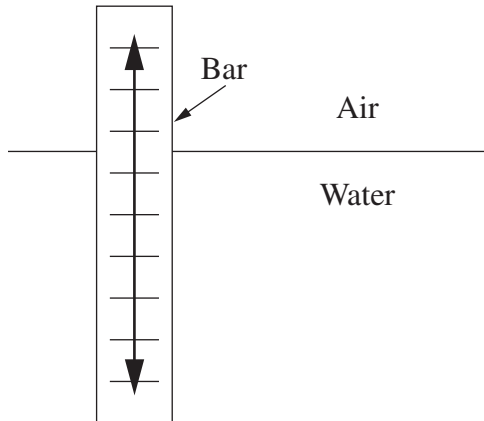
(A) 0 mm

(B) 50 mm

(C) 100 mm

(D) 200 mm

4 What is the name of the region that corrodes in a galvanic cell?

(A) Anode

(B) Base

(C) Cathode

(D) Dipole

5 Deduce from the two microstructures what manufacturing processes were used to form thread shape *X* and thread shape *Y*.
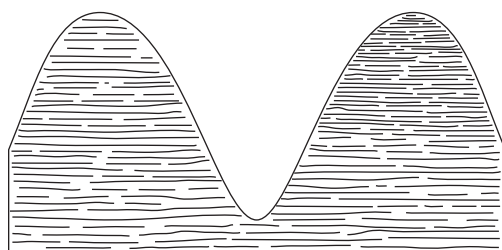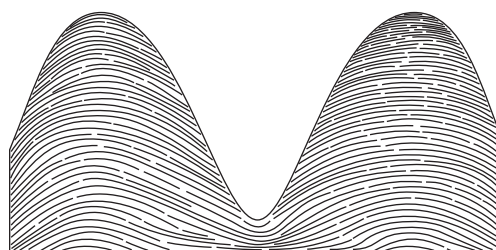
X	*Y*

(A)   *X* by cutting and *Y* by cutting

(B)   *X* by rolling and *Y* by rolling

(C)   *X* by cutting and *Y* by rolling

(D)   *X* by rolling and *Y* by cutting

6 A 12 volt lamp draws a current of 5 amps. A single battery is rated at 6 volts and 20 amp hours.

Which of the following battery arrangements will power the lamp at 12 volts for 8 hours?

(A)
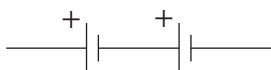
(B)
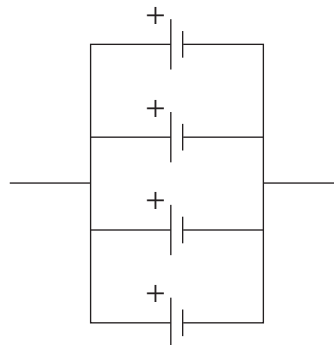
(C)
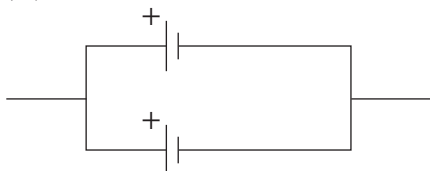
(D)
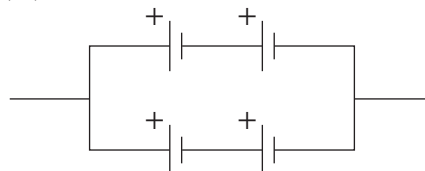
7 The cross-sections of two beams (*A* and *B*) are shown. The beams are loaded with an identical force P.

beam *A*   beam *B*
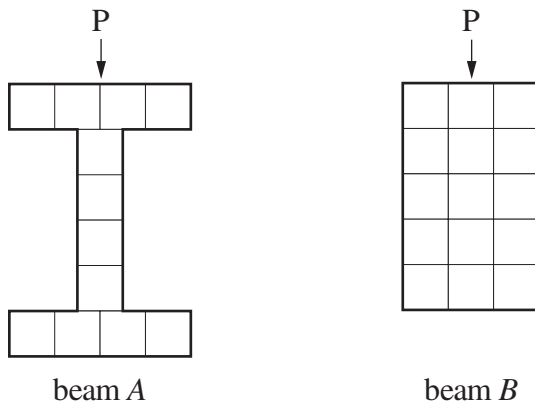
The maximum bending stress developed in beam *A* is less than that in beam *B*.

Which of the statements correctly explains the lower bending stress in beam *A*?

(A)   The distance between the top surface and neutral axis is equal in beams *A* and *B*.

(B)   The distance between the top surface and neutral axis is greater in beam *A* than in beam *B*.

(C)   The distance between the top surface and neutral axis is less in beam *A* than in beam *B*.

(D)   The distance between the top surface and neutral axis of beam A is three times as large as the corresponding distance in beam *B*.

8 Why are high voltages (330 kV) used in the transmission of electricity over the national electrical grid?

(A)   To increase safety

(B)   To increase current

(C)   To reduce resistance

(D)   To reduce power loss

9 The symbols and truth tables for two logic gates are shown.

OR GATE

AND GATE

Input 1
Input 2 ——⊃D—— Output

Input 1
Input 2 ——D—— Output
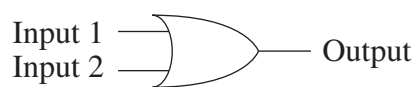
Input 1	Input 2	Output
0	0	0
0	1	1
1	0	1
1	1	1

Input 1	Input 2	Output
0	0	0
0	1	0
1	0	0
1	1	1

In the circuit shown, what inputs are required to obtain an output of 1?

Input X
Input Y
Input Z —— Output = 1
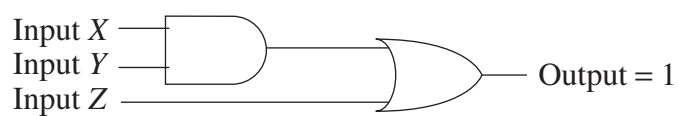
	Input X	*Input Y*	*Input Z*
(A)	0	0	0
(B)	0	1	0
(C)	1	0	0
(D)	1	1	0

10 A pole is supported by a cable which joins point P to G. The drawing scale is 1:100.
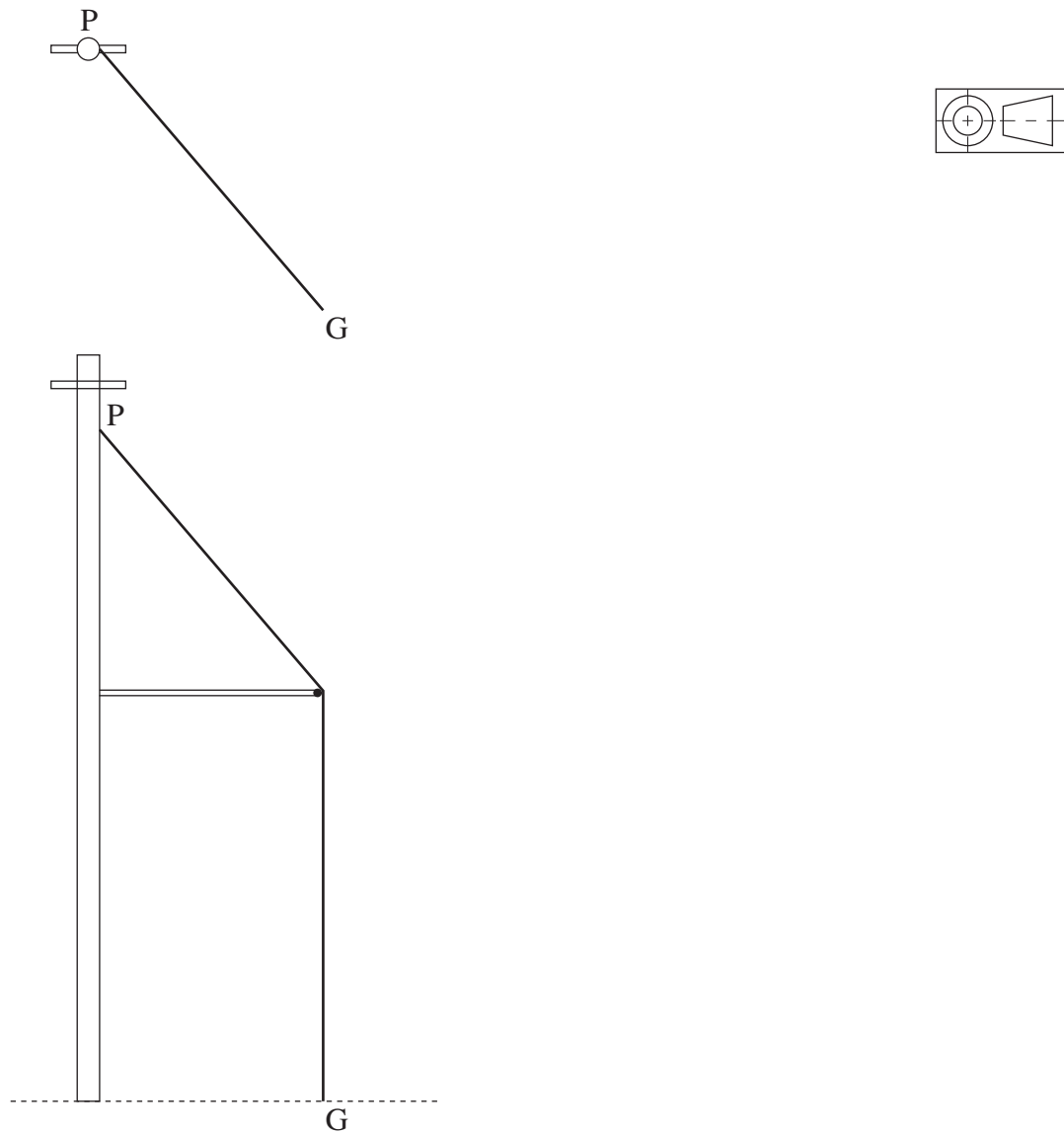
What is the true length (TL) of cable PG?

(A) 100 mm

(B) 10.0 m

(C) 11.2 m

(D) 14.5 m

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Engineering Studies

Centre Number

Section II

Student Number

70 marks
Attempt Questions 11–16
Allow about 2 hours for this section

Answer the questions in the spaces provided.

Marks

Question 11 — Historical and Societal Influences, and the Scope of the Profession (10 marks)

(a) An old and a new racing car are shown.

Car *X*   Car *Y*

(i) Describe TWO engineering innovations that have been applied in the design of the shape of Car *Y* that were not applied in Car *X*.

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– 9 –

Question 11 (continued)

    (ii)   Name and describe a process used to join the body panels in car *X*.   **2**

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(b)   Outline the role of an engineer as a project manager.   **2**

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(c)   Explain environmental issues that an engineer would need to consider in the design of a proposed new car race track.   **3**

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End of Question 11

Engineering Studies

Section II (continued)

Marks

Question 12 — Civil Structures (10 marks)

(a)   A truss, loaded as shown, is used to support a 50 kg electronic display.
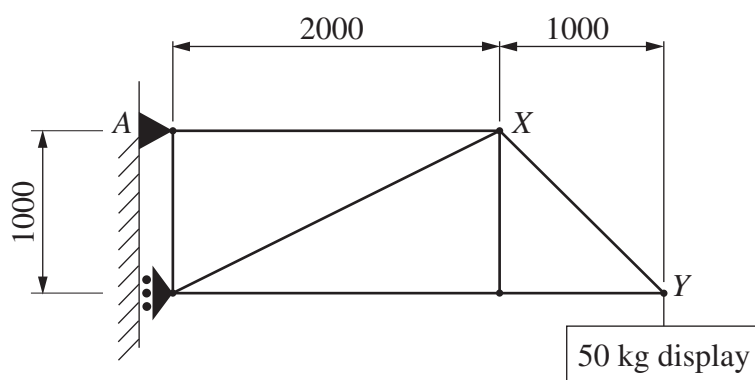
(i)   Calculate the horizontal and vertical reactions at the support *A*.   **2**

Horizontal reaction .... N

Vertical reaction .... N

(ii)   Calculate the tensile force in member *XY*.   **2**

Tensile force .... N

Question 12 (continued)

(b) A boom gate at a car park supports a 10 kg sign. The bending moment diagram (BMD) for the boom gate in this situation is shown. The mass of the boom gate is not being considered.
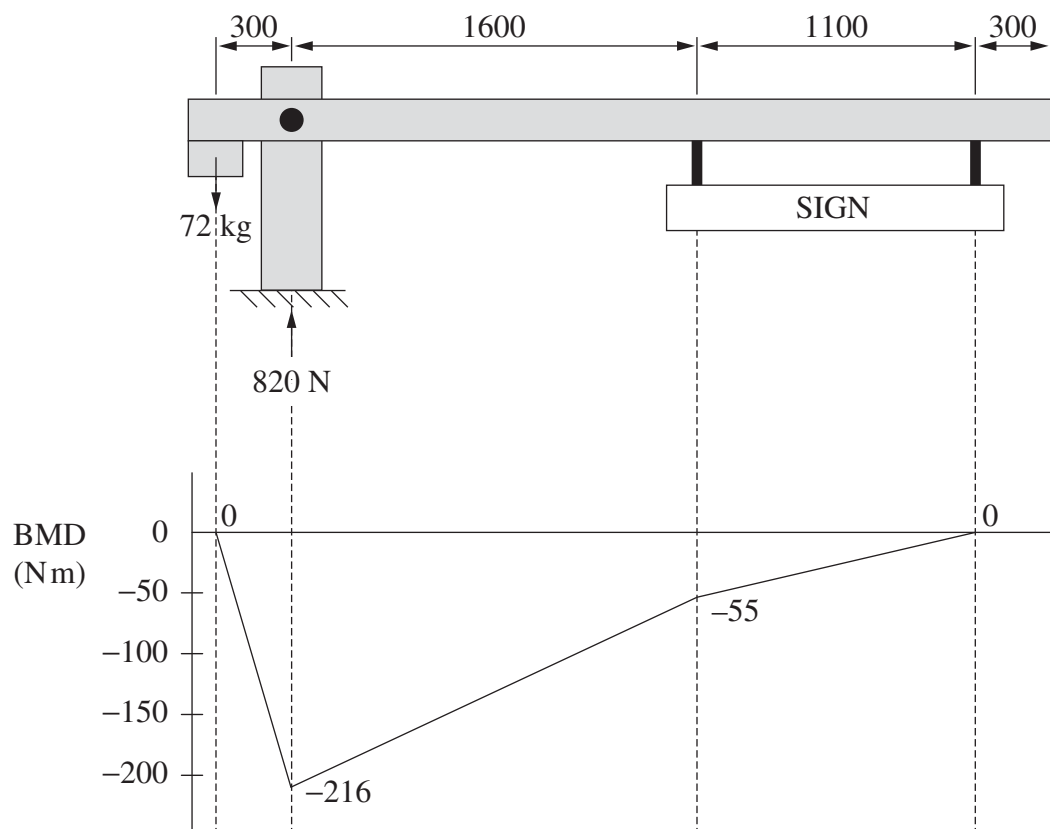
(i) Draw the shear force diagram (SFD), on the axis provided, for the boom gate. Assume $g = 10 \text{ m s}^{-2}$.

2

Question 12 continues on page 13

– 12 –

Question 12 (continued)

(ii) The boom is made from a 100 mm square hollow section with a second moment of area of 1.55×10^{-6} m^4. **2**

Calculate the maximum bending stress in the beam.

.... MPa

(c) The cross-section of a reinforced concrete crash barrier used to protect spectators is shown. **2**

Reinforcing steel
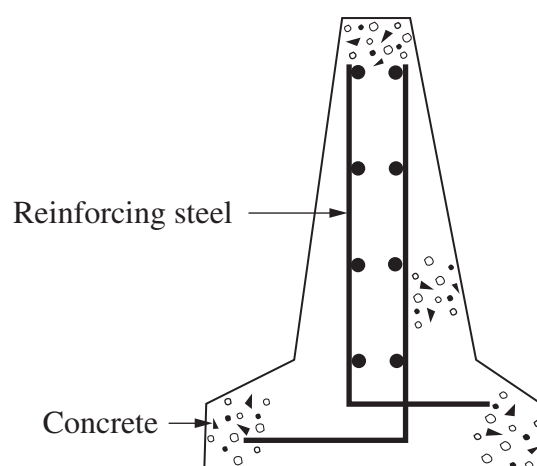
Concrete

Explain how steel and concrete work together effectively in the crash barrier.

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End of Question 12

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Engineering Studies

Section II (continued)

Centre Number

Student Number

Marks

Question 13 — Personal and Public Transport (10 marks)

Electric trams are used in many cities to transport people.

(a)   (i)   State ONE advantage and ONE disadvantage of using a DC motor   **2**
              compared to an AC motor to drive the tram.

              Advantage ....

              ....

              Disadvantage ....

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        (ii)   Explain the role of the brushes and commutator in a DC motor.   **2**

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– 15 –

Question 13 (continued)

(b)　(i)　A steel drive shaft for the tram is heat treated to improve its service properties. **2**

Outline a suitable heat treatment process for this purpose.

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　　　(ii)　Describe a suitable test to check for non-visible flaws in the drive shaft at the time of manufacturing. **2**

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(c)　The rolling resistance of a 11.2 tonne tram is calculated to be 15 kN. The tram travels on a level track for 2.7 kilometres. The time taken for the journey is 4 minutes. **2**

Calculate the power consumed.

.... kW

End of Question 13

Question 14 — Lifting Devices (10 marks)

Question 14 — Lifting Devices (10 marks)

A 3200 kg crash recovery vehicle is used to lift an 853 kg racing car as shown.

Scale 1 : 50

cable →

boom →

C G

1000

2900

3000

A

B

C
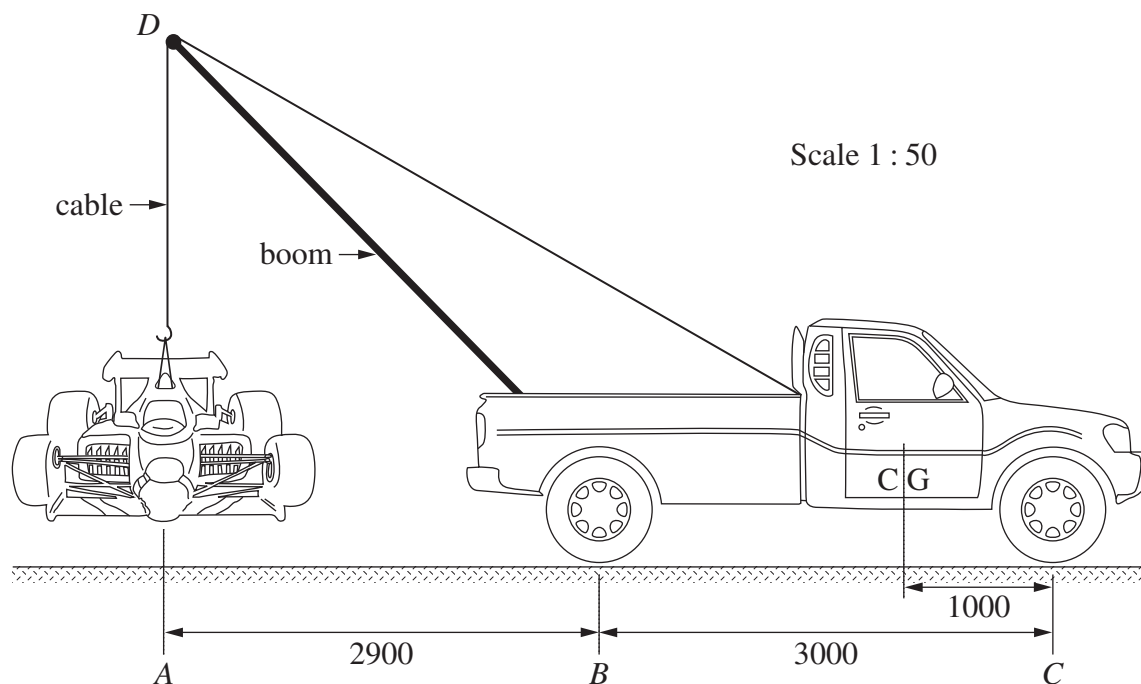
(a)   (i)   Calculate the magnitude of the force in the cable when the racing car is suspended.   **1**

.... kN

Question 14 continues on page 19

– 18 –

Question 14 (continued)

(ii) Calculate the maximum mass that can be suspended before the front wheels of the crash recovery vehicle will be on the verge of lifting off the ground.

2

.... kg

(b) The crash recovery vehicle uses a multi-strand cable attached to a winch to lift the racing car.

(i) Explain why a 10 mm multi-strand cable is used rather than a 10 mm single strand wire.

2

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(ii) A single strand of the cable is $\varnothing 2$ mm. When the strand is loaded with a force of 1.5 kN, the strain in the strand is 0.25%.

2

Calculate Young's Modulus (E) for the material.

.... MPa

Question 14 continues on page 20

Question 14 (continued)

(c)   Gears in a winch are manufactured by powder forming.

      Describe this method of manufacturing and state ONE advantage of this method.

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End of Question 14

Engineering Studies

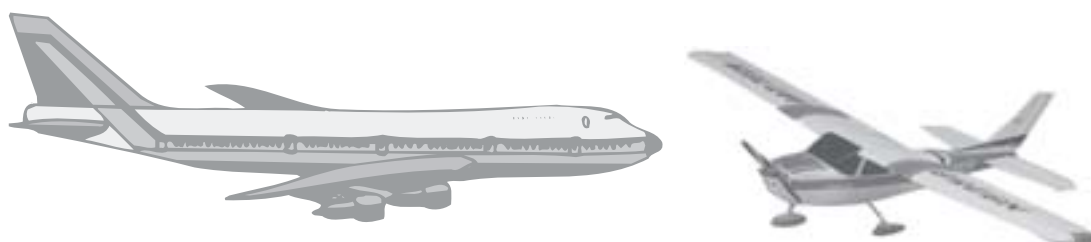**Section II (continued)**

Centre Number

Student Number

Marks

Question 15 — Aeronautical Engineering (15 marks)

(a) Both jet and piston engines can be used on aircraft.   **2**

Explain why these different engine types are suitable for the aircraft shown above.

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(b) Explain why metals are more susceptible to corrosion when used in aircraft.   **2**

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350

Question 15 (continued)

(c)   State an advantage and a disadvantage of the use of composite materials in aircraft.   **2**
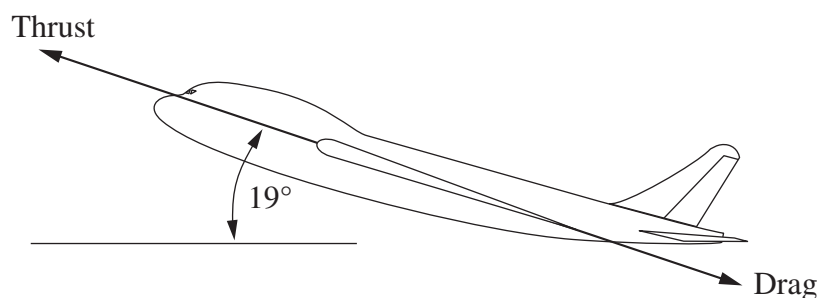
Advantage ....

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Disadvantage ....

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(d)   An aircraft is travelling at constant velocity at an incline of 19°.   **2**

The mass of the aircraft is 85 tonne.

Determine the magnitude of the lift in this situation.

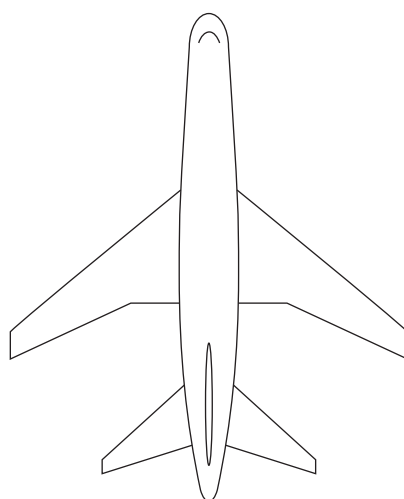................................ kN

Question 15 continues on page 23
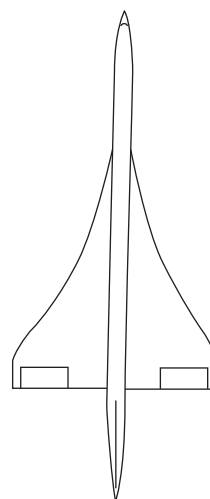
Question 15 (continued)

(e) Aircraft *X* and Aircraft *Y* have different shapes.

3

Explain how the shape of aircraft affects lift and drag.

Aircraft *X*   Aircraft *Y*

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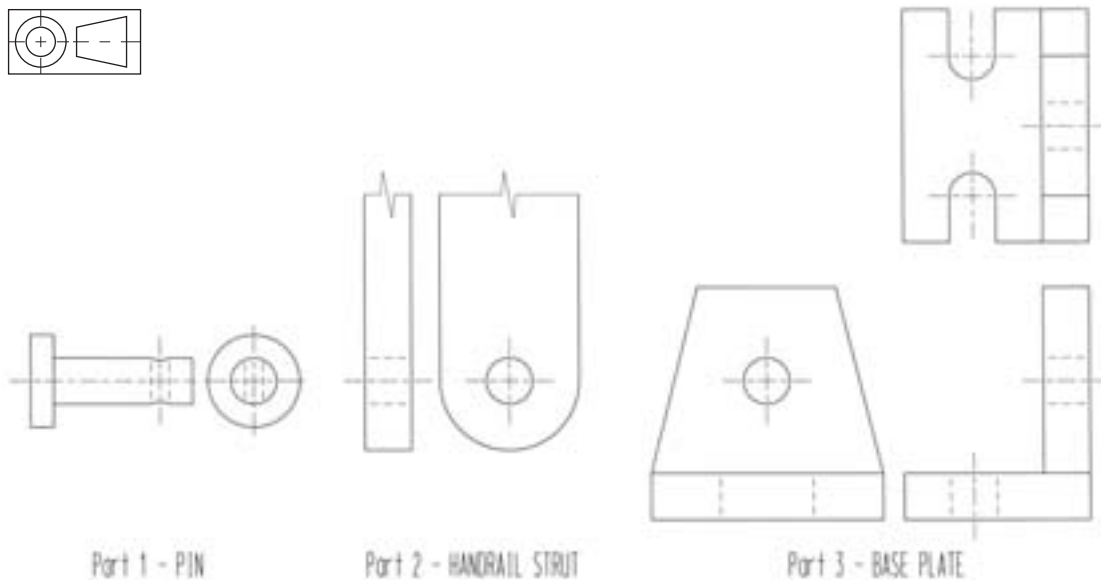
Question 15 continues on page 24

Question 15 (continued)

(f)   From information in the orthogonal views, draw a pictorial sketch of the parts **4** assembled. Use the same scale for the sketch as used in the orthogonal drawings.

Part 1 – PIN   Part 2 – HANDRAIL STRUT   Part 3 – BASE PLATE

End of Question 15

Engineering Studies

Section II (continued)

Centre Number

Student Number

Marks

Question 16 — Telecommunication (15 marks)

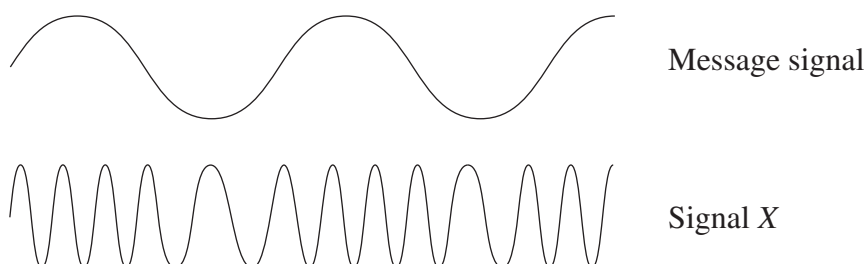Telecommunication systems use various forms of modulation.

(a)   (i)   List THREE parameters of a sine wave that can be varied for the purpose of modulation.   **2**

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(ii)   The diagram shows a message signal and a signal resulting from a form of modulation.   **1**

Message signal

Signal *X*

Identify the form of modulation producing Signal *X*.

Signal *X*: ....

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– 25 –

Question 16 (continued)

(iii) Various systems within a race car can cause interference to radio signals.　**2**

Identify ONE source of interference and explain why an FM signal is relatively immune to this form of interference.

Source: ....

Explanation: ....

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(b)　(i)　Name the band in the electromagnetic spectrum used in satellite communication systems.　**1**

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(ii)　Attenuation occurs in fibre-optic cables.　**2**

Name ONE type of attenuation and outline the reason for this signal loss.

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(c)　Name a semiconductor device and describe a function it performs in an electronic circuit.　**2**
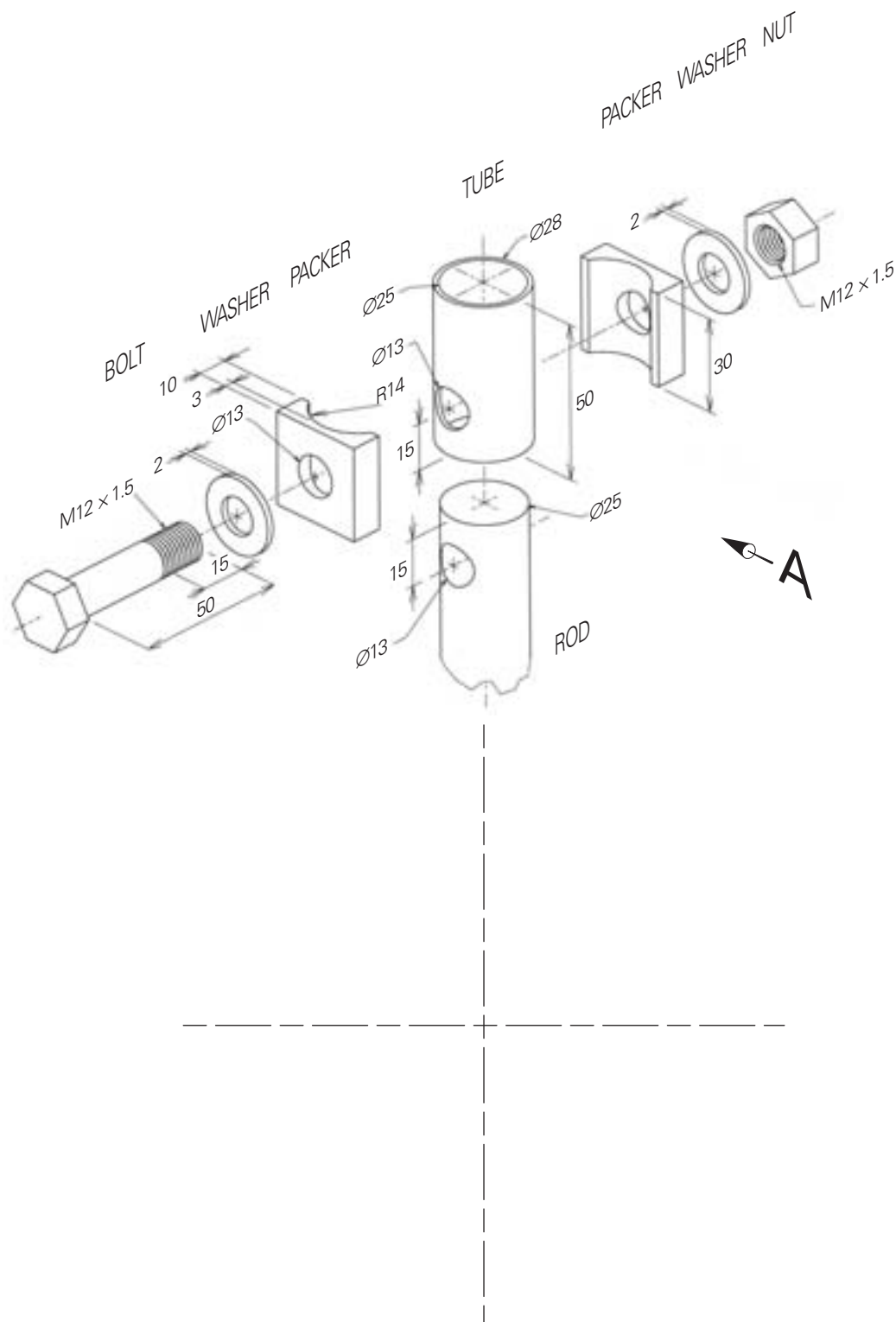
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Question 16 (continued)

(d)   On the vertical and horizontal axes provided, draw a fully assembled section **5**
       view of the parts from direction A.

End of Question 16

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Engineering Studies

Section III

Centre Number

Student Number

20 marks
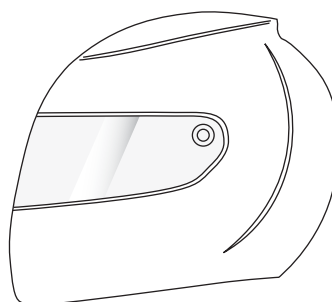**Attempt Questions 17–18**
Allow about 40 minutes for this section

Answer the questions in the spaces provided.

Marks

Question 17 — Engineering and the Engineering Report (10 marks)

A motorcycle helmet must meet specific standards before being approved for use.

(a)   Describe THREE engineering criteria that could be used to assess the   **2**
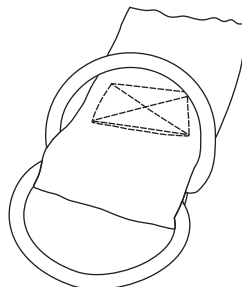performance of a helmet.

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Question 17 (continued)

A feature of the helmet is the strap system that secures the helmet to the rider. The system includes a flexible strap and a double D-ring.

(b) Describe a suitable engineering test to determine whether the strap system meets requirements.   **2**
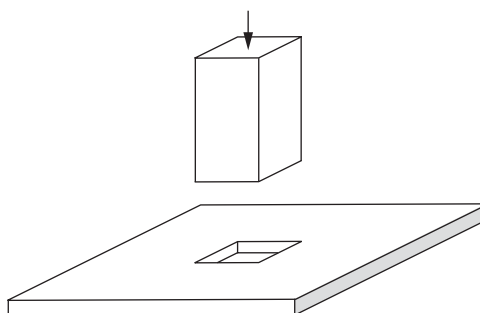
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(c) The polycarbonate visor of the helmet must resist a 290 N load when tested with a 5 mm × 5 mm punch. The maximum allowable shear stress in the material is 9.67 MPa.   **3**

Calculate the minimum thickness of the visor.

minimum thickness ....

Question 17 continues on page 31

Question 17 (continued)

(d) Engineers need to select materials for the motorbike helmet. Acrylonitrile **3**
butadiene styrene (ABS) is a typical choice for the exterior shell of the helmet.

Explain the in-service and manufacturing properties of acrylonitrile butadiene
styrene (ABS) that make it a suitable choice.

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End of Question 17

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Centre Number
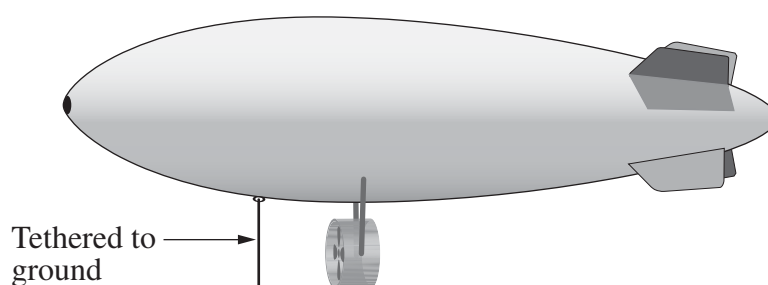
Student Number

Marks

Question 18 — Engineering and the Engineering Report (10 marks)

Airships use lighter-than-air gas to achieve lift. An electric motor drives a propeller for additional flight control. In this instance the airship is tethered to the ground.

Tethered to ground

(a)   An engineering assessment must be made regarding the safety of the airship as an aerial camera platform.

2

Discuss significant safety considerations the engineer would include in the engineering report.
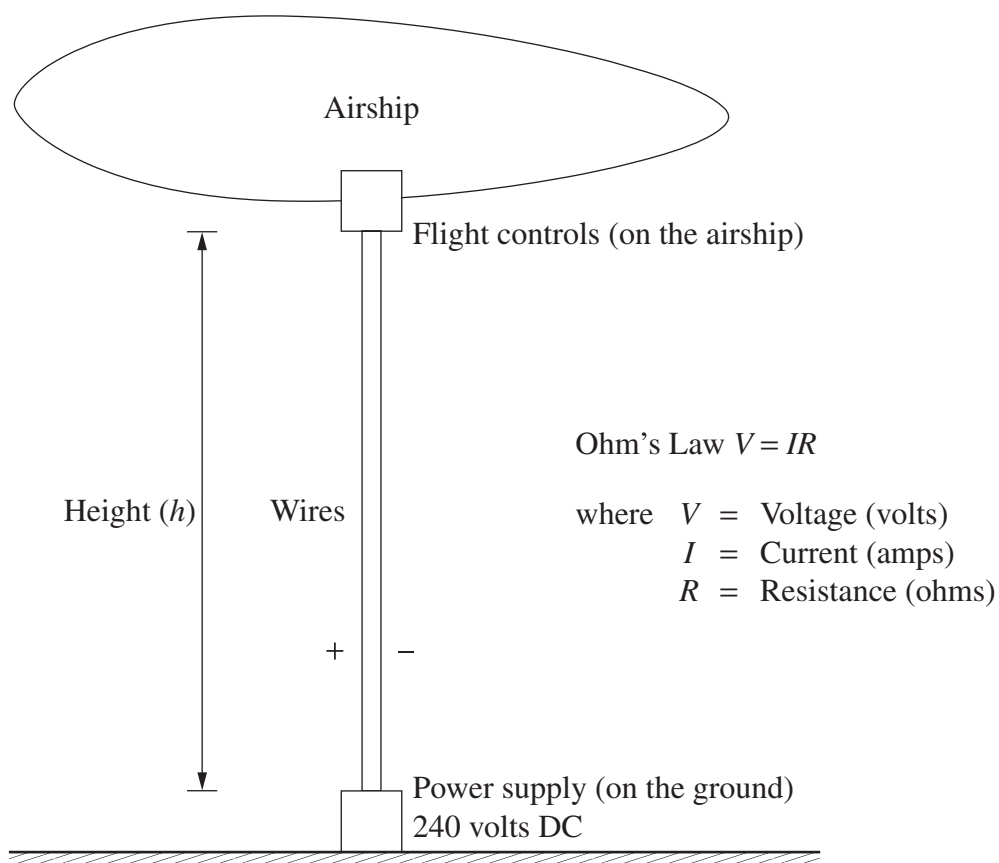
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353   – 33 –

Question 18 (continued)

(b)   The flight controls aboard the airship are operated from the ground. The flight   **3**
controls draw 5 amps and require a minimum of 195 volts for correct operation.
The power supply, located on the ground, is 240 volts DC and the resistance of
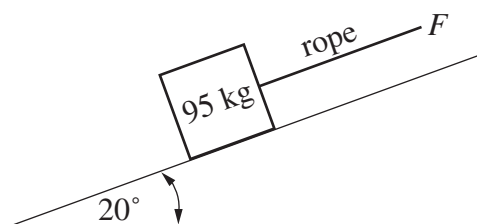each copper wire is 0.02 Ω/m.

Determine the maximum operating height of the airship for correct operation of
the flight controls.

Maximum operating height in metres ....

Question 18 (continued)

(c)   A 95 kg crate of airship parts needs to be loaded onto a truck.
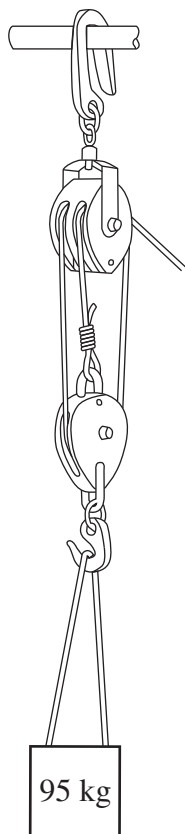

   (i)   Determine the minimum force (F) in the rope required to move the crate   **2**
         up the ramp if $\mu = 0.25$ and the mass of the crate is 95 kg.

Force (F) ....

Question 18 continues on page 36

Question 18 (continued)

    (ii)   An alternative method of lifting the crate would be using a block and tackle.

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95 kg

Discuss the engineering advantages of both lifting systems.

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End of Paper

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FORMULAE SHEET

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Force, Moments

$F = ma$; $M = Fd$

If a body is in equilibrium, then $\sum F_x = 0$; $\sum F_y = 0$; $\sum M = 0$

Friction

$F = \mu N$; $\mu = \tan\phi$

Energy, Work, Power

$KE = \frac{1}{2}mv^2$; $PE = mgh$; $W = Fs = \Delta PE + \Delta KE$; $P = \dfrac{W}{t}$

Pressure

$P = \dfrac{F}{A}$; $P = P_o + \rho gh$

Stress and Strain

$\sigma = \dfrac{F}{A}$; $\varepsilon = \dfrac{e}{L}$; $E = \dfrac{\sigma}{\varepsilon}$; $\sigma = \dfrac{My}{I}$

$\sigma_{\text{allowable}} = \dfrac{\sigma_{yield}}{F \text{ of } S}$ (Ductile); $\sigma_{\text{allowable}} = \dfrac{\sigma_{UTS}}{F \text{ of } S}$ (Brittle)

Machines

$MA = \dfrac{L}{E}$; $VR = \dfrac{d_E}{d_L}$; $\eta = \dfrac{MA}{VR}$

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